Concept of Operations for Connected Vehicle Road-Weather Applications

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Purpose

- Introduce the scope of the ConOps
- Discuss potential Connected Vehicle Road-Weather applications
- Obtain feedback on applications needs and concepts

Justification for Change

- Impacts of road-weather on safety, mobility, and productivity are well understood
- Road-weather environment is unique; and requires both weather and road weather products (e.g., pavement forecasting) presented in a transportation context

Current Situation

- FHWA Road Weather Management Program addressing the problem through targeted and coordinated R&D
- State and Local transportation agencies investing in implementation of road weather management technologies
- Academic and research community conducting advanced research
- Private sector offering commercial products and services

Need for Further Work

- Need to significantly reduce the weather related crashes, injuries and fatalities
- Road users need high resolution weather and road condition information
- Road managers need ability to predict and manage conditions at a more granular level
- Need to understand driver behavior under a variety of weather and road conditions
- Need to understand how infrastructure-based systems should be optimized in response to changing weather conditions

Opportunities from Connected Vehicles

- Connected vehicles can dramatically change the road weather environment:
  - Provide a continuous picture of what's happening on the roadways
  - Dramatically enhance existing road weather management systems
  - Create transformative new applications that leverage connected vehicle data
  - Bring additional capabilities to other connected vehicle safety, mobility, and environmental applications

Taxonomy of Application Areas

Category	Examples
Road Weather Alerts & Warnings	• Motorist Advisories & Warnings • EnableATIS
State & Local Agency-Based Applications	• Enhanced MDSS • Info for Maintenance Mgmt Systems • Weather-Responsive Traffic Mgmt • INFLO • Signal/Stop Sign Violation Warnings • Curve Speed & Rollover Warnings
Freight-Based Applications	• Information for freight shippers
EMS/First Responder Applications	• Info & Routing support for emergency responders

Connected Vehicle Road-Weather Apps

- Motorist advisories and warnings
- Enhanced maintenance decision support system
- Information for maintenance and fleet management systems
- Variable speed limits for weather-responsive traffic management (WRTM example)
- Information for freight shippers
- Information and routing support for emergency responders

Enhanced-MDSS - Background

- Decision-support tool integrates road-weather forecasts, rules of practice, and resources to recommend treatment strategies
- Effectiveness of recommendations related to quality and extent of inputs
- Connected vehicles will provide expanded data acquisition
- Enhanced-MDSS will generate improved plans for maintenance managers; in turn, better information provided to operators

Enhanced-MDSS Application

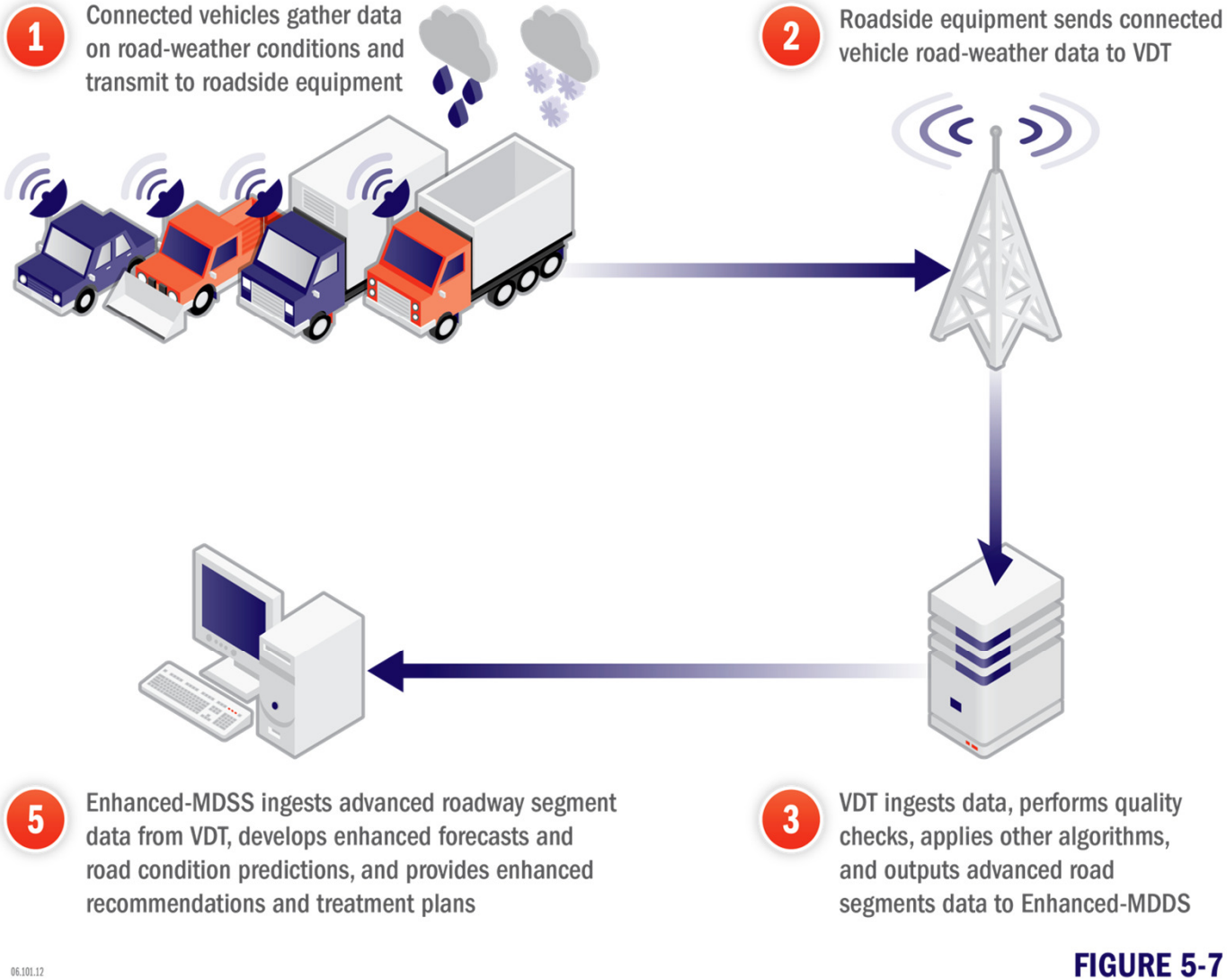


FIGURE 5-7

Principal System Components

- Data Acquisition Subsystem
  - Connected vehicle onboard and roadside equipment
  - General public and commercial vehicles; specialty vehicles, and public fleet vehicles
  - Cars and trucks provide BSM Parts 1 & 2 data; agency vehicles provide data from specialty sensors
- Data Processing Subsystem
  - Data sent to VDT to generate segment-based outputs for the Enhanced-MDSS
  - Outputs assimilated in back-end processors for use in weather & pavement temp models
  - Supplement other data in Road Weather Forecast System and Road Condition & Treatment Module

Principal System Components

- User Interface System
  - Maintenance personnel interact with system in similar manner to existing MDSS
  - New decision support tools may be developed to use detailed segment-specific data
  - New techniques required to deliver plans and recommendations to operators

Maintenance and Fleet Management System - Background

- Viewed as stand-alone app and adjunct to Enhanced-MDSS
- Systems concerned with control of physical assets – vehicles, equipment, materials
- Purposes include:
  - Manage material and fuel usage and purchases
  - Allocation of staff and other resources
  - Equipment maintenance planning & scheduling
  - Budget monitoring and forecasting
  - Acquisition and procurement support

Maintenance and Fleet Management System - Background

- Connected vehicles can provide non-road weather data
  - Diagnostic information, vehicle component status, location of vehicles, types/amount of materials
- Potential to automate data inputs year-round
- Selected data can be passed to Enhanced-MDSS to refine recommended winter weather response plans and recommendations

Maintenance & Fleet Management Application

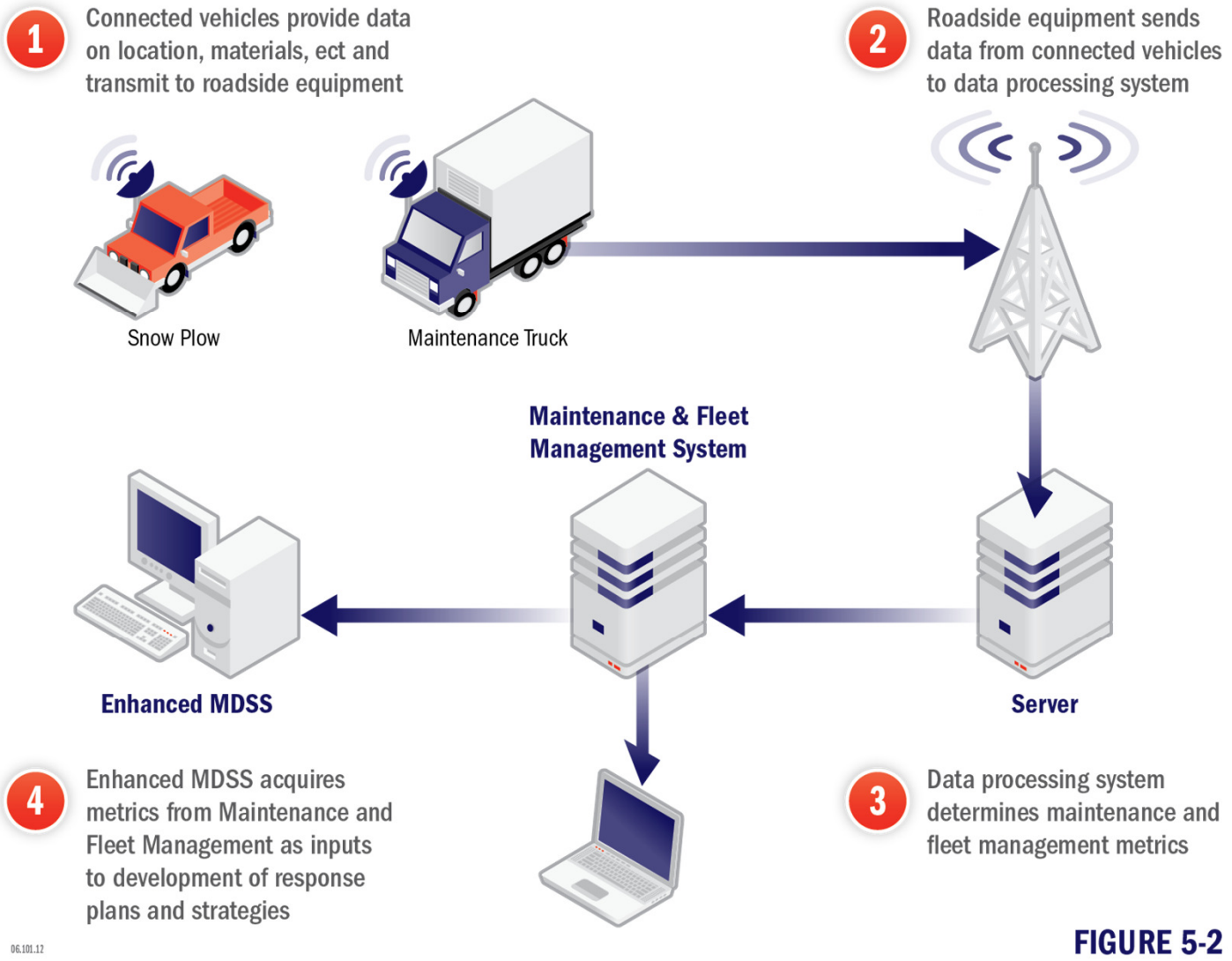


FIGURE 5-2

Principal System Components

- Data Acquisition Subsystem
  - Connected vehicle onboard and roadside equipment
  - Data collected year-round from all maintenance assets
  - Diagnostic data via CANBus; other data from specialty sensors
- Data Processing Subsystem
  - Connected vehicle data via backhaul to remote processing system
  - Outputs to Maintenance and Fleet Management System; onward transmission to E-MDSS as necessary

Principal System Components

- User Interface Subsystem
  - Users interact with systems in similar manner to existing system
  - New decision support tools may be required for E-MDSS to use connected vehicle data

Variable Speed Limits for WRTM - Background

- One example of a road-weather WRTM strategy
- Other connected vehicle applications considering road-weather information
  - Signal and stop sign violations, speed harmonization, queue warning, curve speed warning
- VSL provide real-time info on appropriate speeds for current conditions and warn drivers of approaching road conditions

Variable Speed Limits for WRTM - Background

- Gaining attention in work zone management
  - Multiple roadside monitoring and display trailers detect speed and conditions, consider roadwork activities, and determine appropriate speed
- Connected vehicle data can enhance operations and improve work zone safety during severe weather
  - Additional road-weather info used in algorithms to refine posted speeds to reflect prevailing weather and road conditions

Variable Speed Limits for WRTM

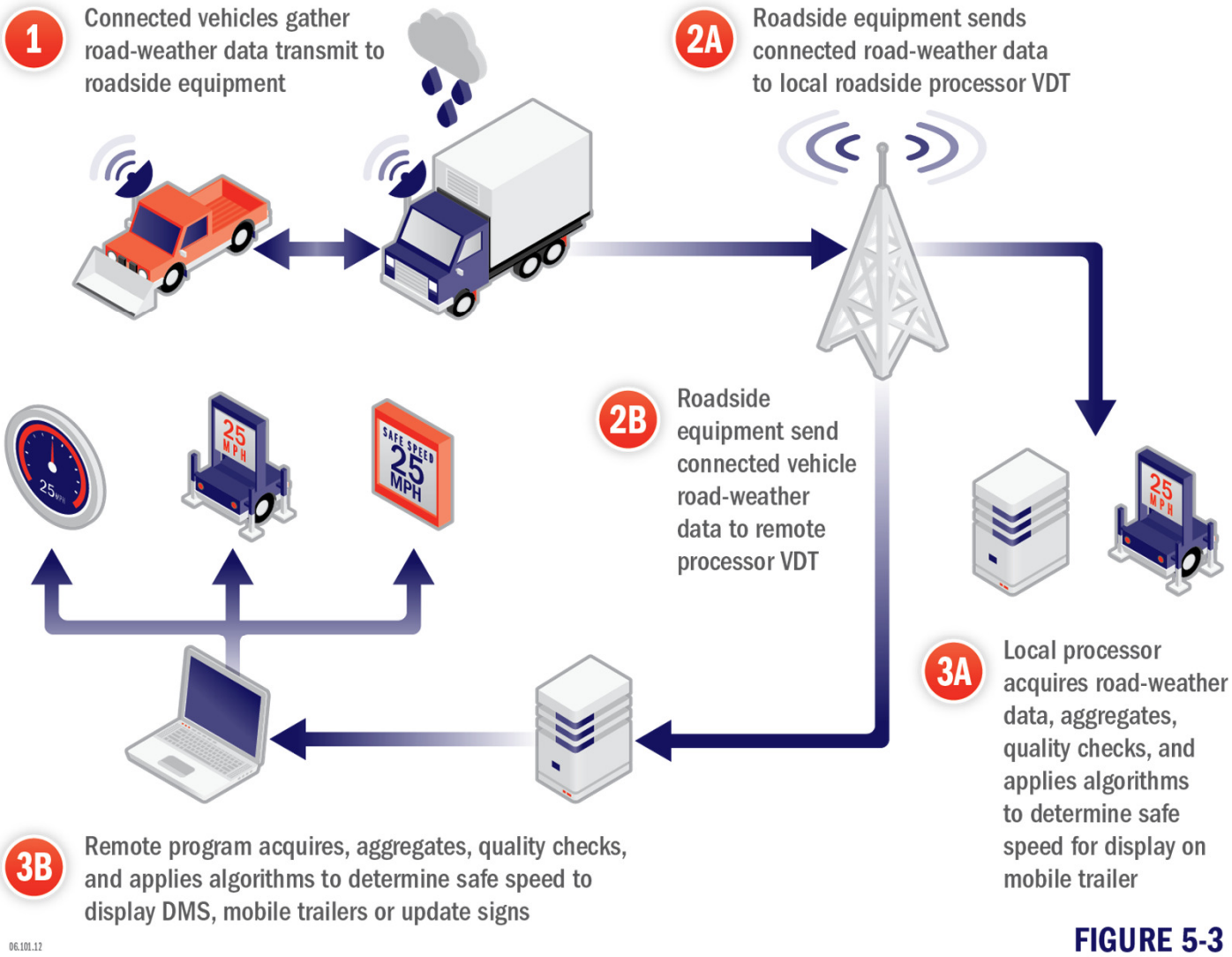


FIGURE 5-3

Principal System Components

- Data Acquisition Subsystem
  - Connected vehicle onboard and roadside equipment gather data from all vehicles
- Data Processing Subsystem – two scenarios
  - Data processing at roadside using systems on portable trailers; suitable for mobile WZ or no backhaul
  - Data communicated to remote location (TOC or maintenance shed) for processing; suitable for long-term construction or broader VSL applications incorporating DMS or in-vehicle signing

Principal System Components

- Data Processing Subsystem contd.
  - Data processed by VDT, combined with other data (traffic, weather, work zone characteristics) and used in speed limit selection algorithm
- Information Display Subsystems
  - Roadside processing: use mobile display trailers
  - Remote processing: Trailers, freeway/arterial DMS, in-vehicle signs

Motorist Advisories and Warnings - Background

- Access to travel/weather information from multiple sources, providers, and media
  - Traffic incidents and delays, work zones, severe weather events
  - 511 systems, websites, DMS, social media
  - Traditional media outlets
  - NWS Watches, Warnings, Statements, and Advisories and broadcast media outlets use NWS Doppler Radar feeds
  - private sector packaging traveler information with navigation products or as mobile applications

Motorist Advisories and Warnings - Background

- Value of information related to the breadth and quality of the data collection capabilities
- Segment-specific weather and road conditions is not well represented
- Information from connected vehicles will dramatically change this situation
  - Deteriorating road and weather conditions pushed to travelers within a few minutes.
  - With observations and forecasts and additional processing, medium-term to long-term advisories can be provided

Motorist Advisories and Warnings

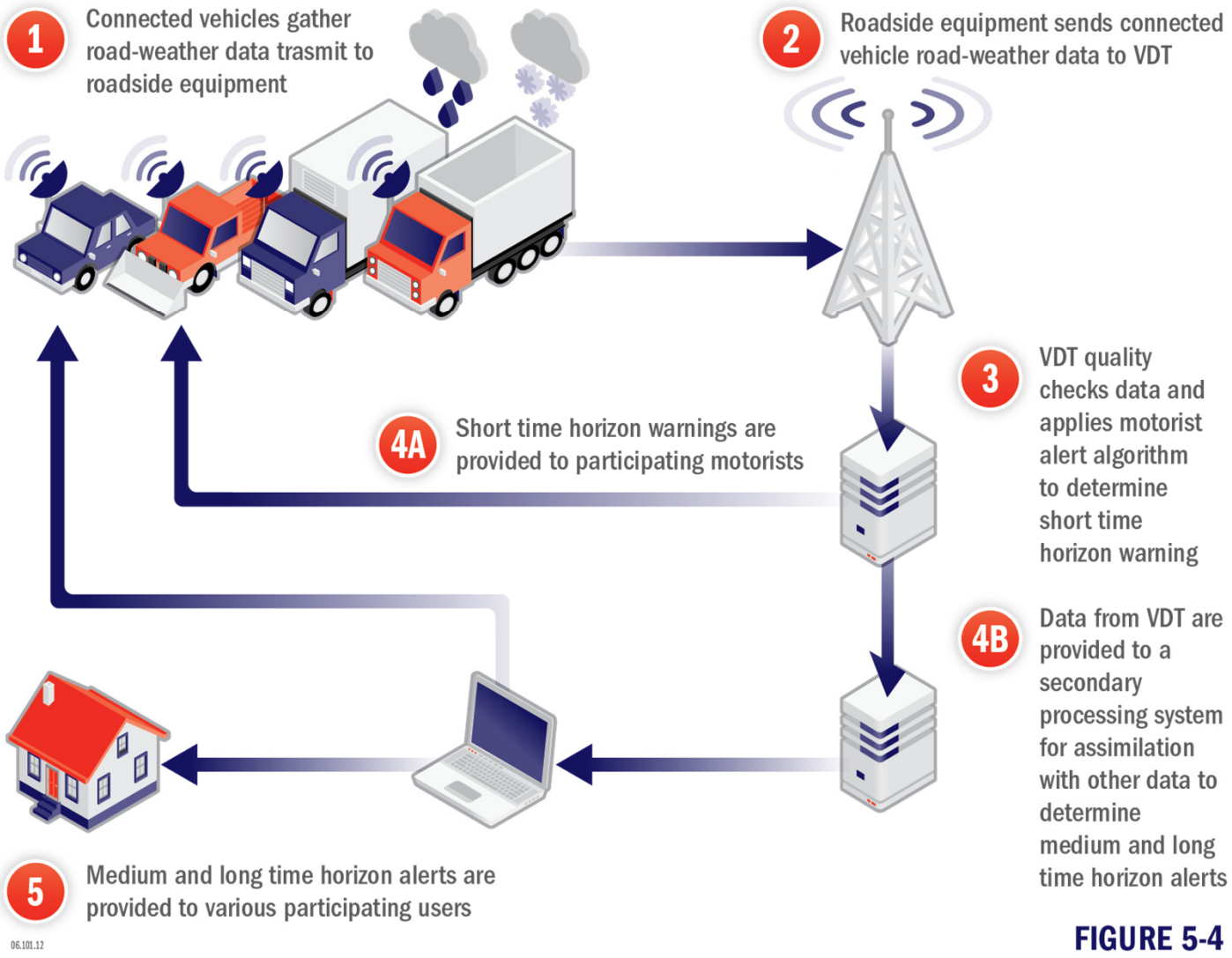


FIGURE 5-4

Principal System Components

- Data Acquisition Subsystem
  - Connected vehicle onboard and roadside equipment
  - General public and commercial vehicles; specialty vehicles, and public fleet vehicles
  - Cars and trucks provide BSM Parts 1 & 2 data; agency vehicles provide data from specialty sensors
- Data Processing Subsystem
  - Data communicated to VDT to generate segment-based outputs that will be provided to a motorist alerts algorithm to create short time horizon alerts
  - Supplement with other data and assimilate in back-end processors for use in weather and pavement temperature models

Principal System Components

- Information Generation Subsystem
  - VDT outputs to other information processing systems to produce tailored information content for end user systems
  - Decision support tools may be developed for traffic and maintenance operations
- End User Interface Subsystems
  - Outputs from motorist alerts algorithm and from other information generation subsystems will be provided in a manner that makes the information accessible through as many end user interfaces as possible

Information for Freight Carriers - Background

- Special case of motorist advisory system
- Truck drivers must consider weather and road conditions to operate vehicles safely and consider approaching weather events to plan Hours-of-Service and parking availability; multi-state information especially important
- Rerouting can present challenges
  - Weight and bridge height restrictions, geometrics, operational factors (e.g., delivery schedules)

Information for Freight Carriers - Background

- Connected vehicles can provide information on deteriorating weather and road conditions that can be pushed to truck drivers and dispatchers
  - Short-time horizon advisories and warnings
  - Medium and long-term advisories to dispatchers to support routing and scheduling decisions
  - Decision support systems could be developed by shippers or commercial providers that consider other factors and restrictions

Information for Freight Carriers

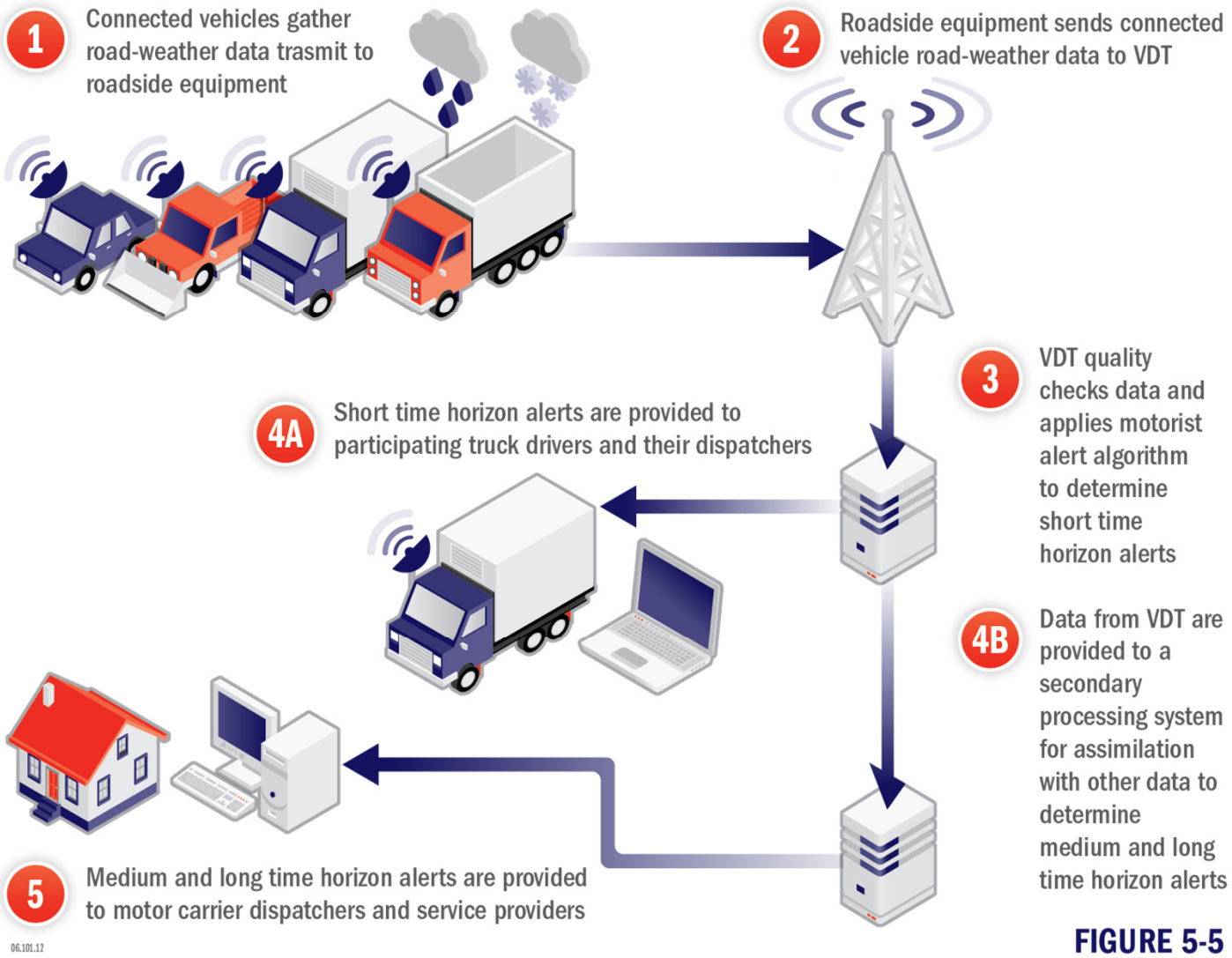


FIGURE 5-5

Principal System Components

- Data Acquisition Subsystem
  - Connected vehicle onboard and roadside equipment gathers data from all vehicles
- Data Processing Subsystem
  - Data delivered to VDT to generate segment-specific short time horizon warnings that are pushed to drivers and dispatchers
  - Outputs supplemented with other data and used in various models to provide carriers or commercial providers with medium to long time horizon alerts for use in their systems

Principal System Components

- Information Generation Subsystem
  - VDT data outputs made available to other information processing systems in shipper facilities or operated by commercial service providers
- End User Interface Subsystems
  - Information from short time horizon algorithm or from other information generation systems must be suitable for display in the truck cab environment

Information and Routing Support for Emergency Responders - Background

- Ambulance drivers, paramedics, and fire & rescue companies need short, medium, and long-term advisories
  - Help drivers operate vehicles safely during weather events
  - Support routing and dispatching decisions
  - Road or lane closures due to snow, flooding or wind-blown debris affects selection of response routes, calculation of response times, and decisions to hand-off calls to another responder

Information & Routing Support for Emergency Responders

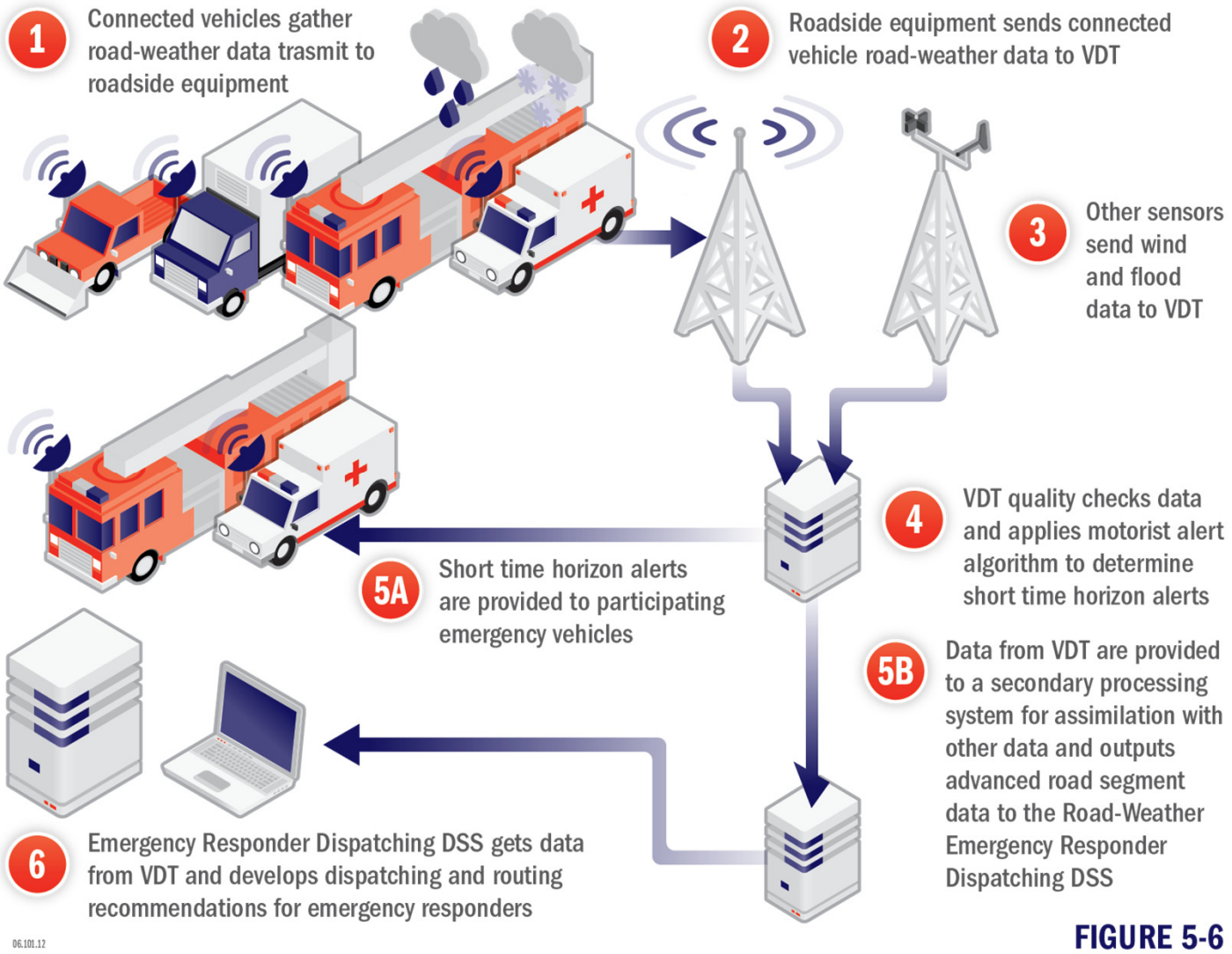


FIGURE 5-6

Principal System Components

- Data Acquisition Subsystem
  - Connected vehicle onboard and roadside equipment acquire data from all vehicle types
- Data Processing Subsystem
  - VDT generates segment-based outputs for use in weather alerts algorithm to generate short-time horizon message provided to operators and dispatchers
  - Outputs supplemented with other data and used in models to generate information for dissemination to Emergency Responder DSS

Principal System Components

- Decision Support System
  - New system may reside in emergency responder facility or transportation agency
  - Analyze interactions between current and forecast road and weather conditions, traffic conditions, and information from agencies (e.g., plowed routes)
- End User Interface Subsystems
  - Requires new subsystems appropriate for the emergency vehicle operator or dispatcher

Operational Policies and Constraints

- Data availability
  - Broad Connected Vehicle Penetration
  - Willingness to deploy specialty sensors
  - Deferred trips during severe weather
- VDT implementation
- Existing system enhancements
- Algorithm and processing system development
- Interfaces to other system
- Deployment coverage

Summary of Impacts

- Operational impacts
  - Need for connected vehicle infrastructure
  - Implementation of new systems
  - Changes to existing systems
  - New data sources and data processing capabilities
  - New operational procedures
  - New training requirements
- Organizational impacts
  - New interactions between public agencies
  - New interactions with private entities

Discussion of Concepts

- Have we identified the correct needs? Can we refine or expand the needs?
- Have we identified appropriate concept/approaches to respond to the needs?
- What are the impediments and constraints to implementation?
- What kind of benefits and costs do we know of?

Enhanced-MDSS Application

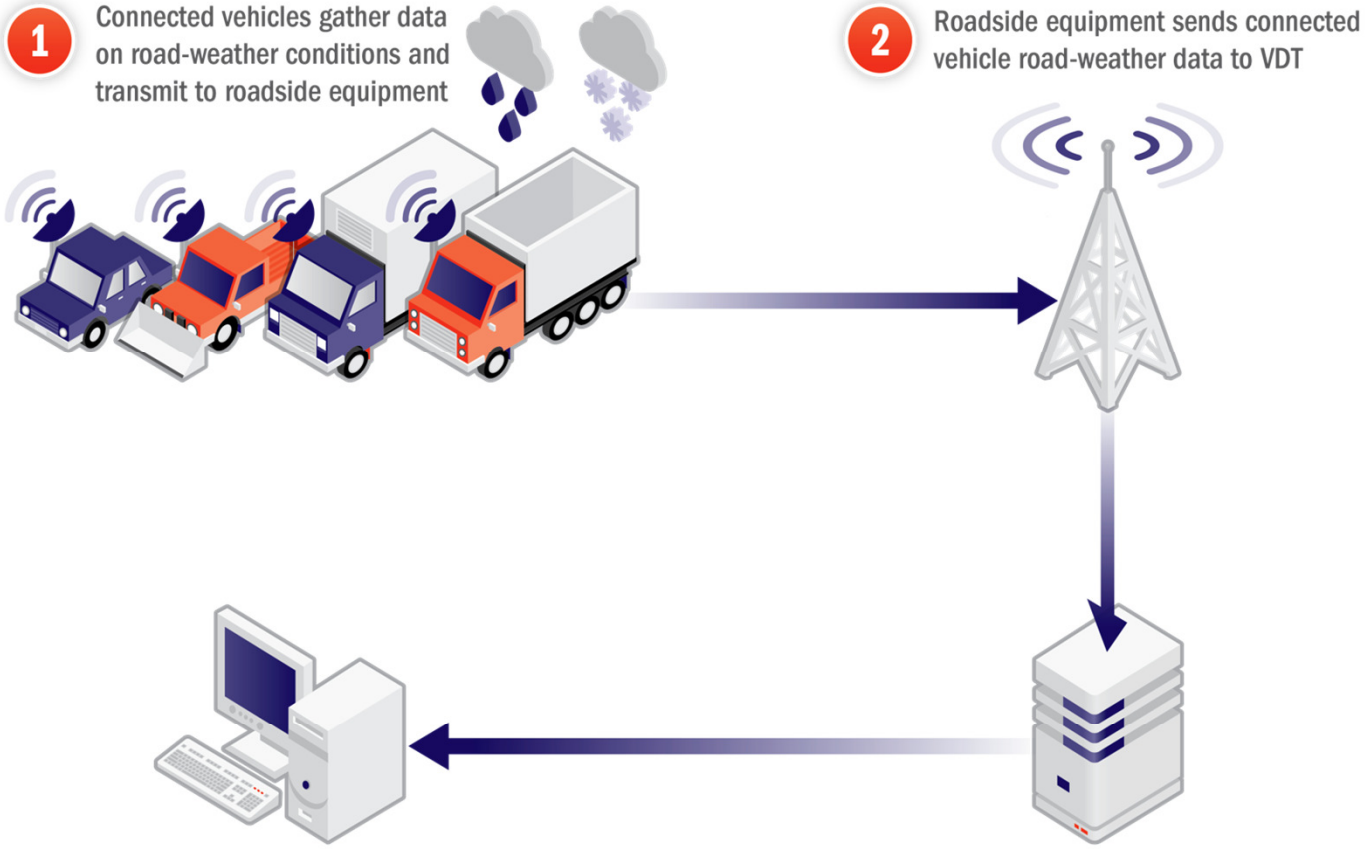


FIGURE 5-7

Maintenance & Fleet Management Application

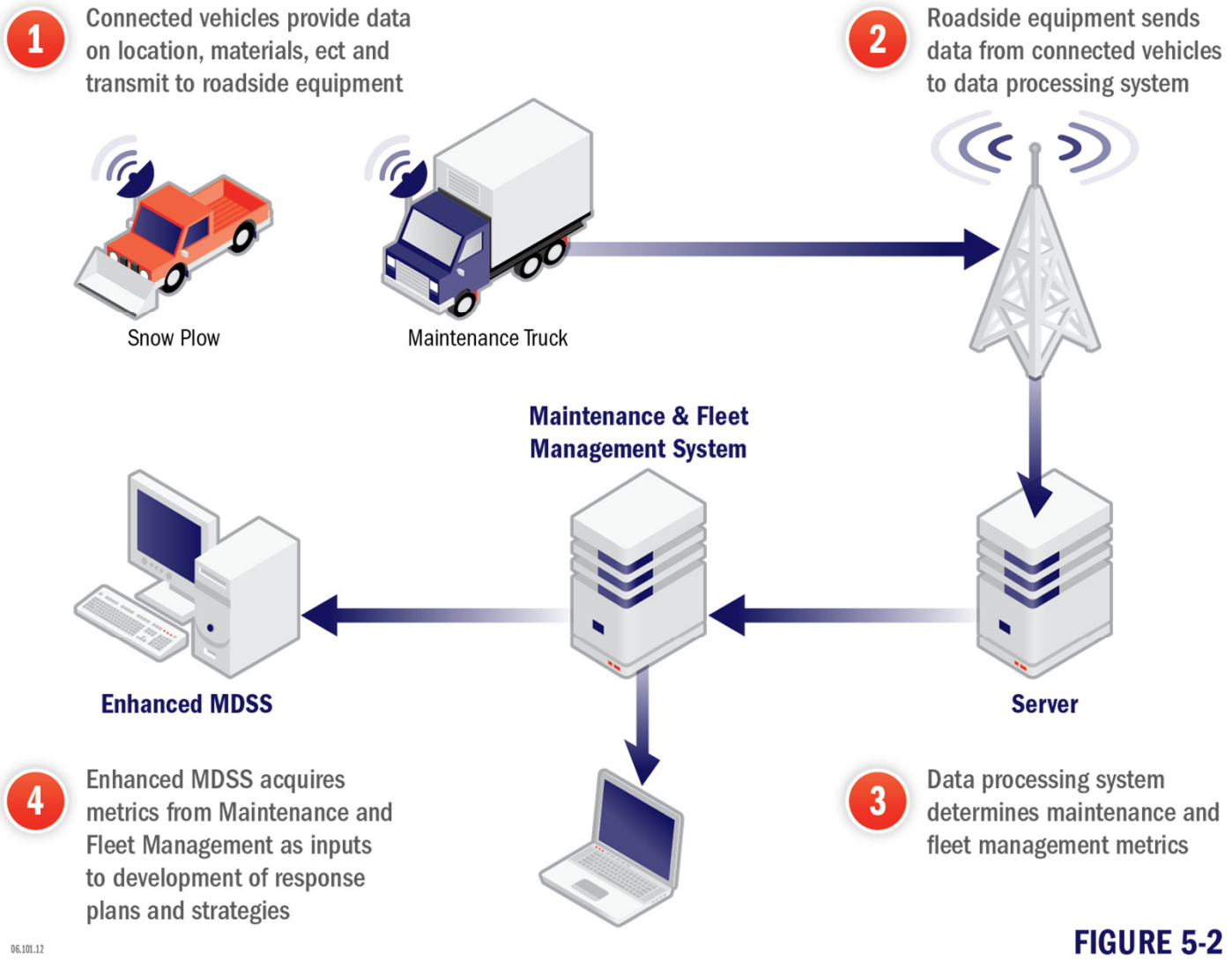


FIGURE 5-2

Variable Speed Limits for WRTM

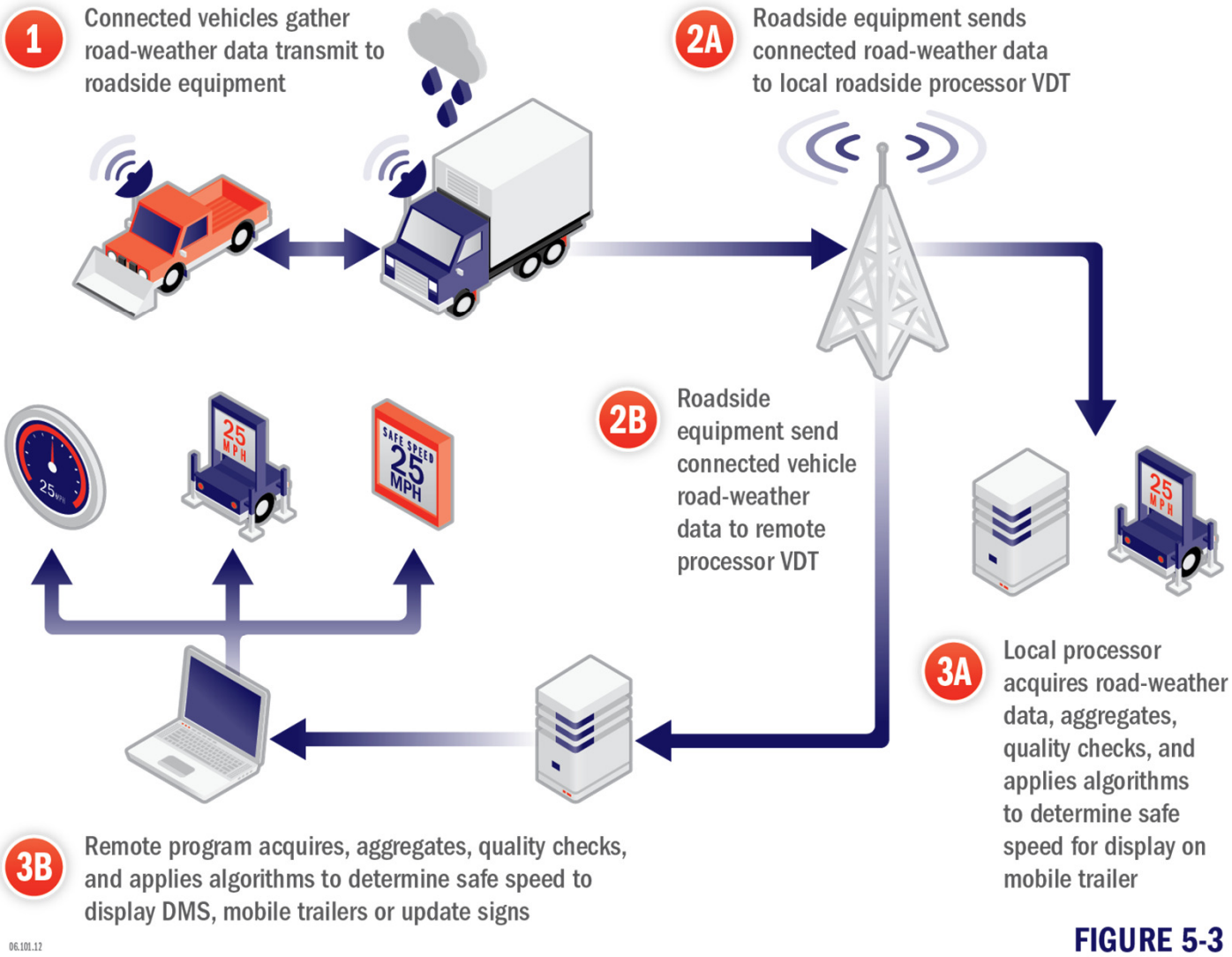


FIGURE 5-3

Motorist Advisories and Warnings

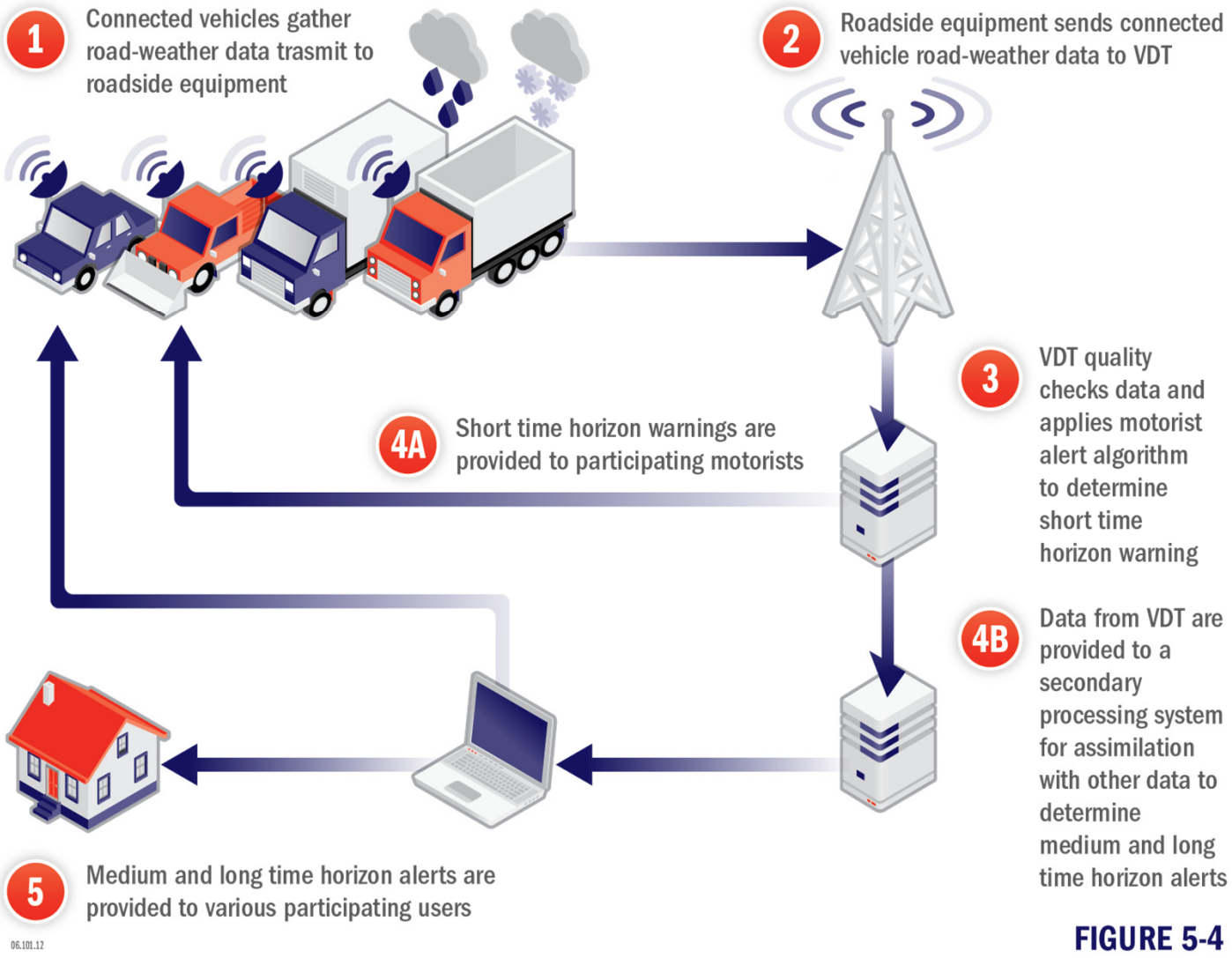


FIGURE 5-4

Information for Freight Carriers

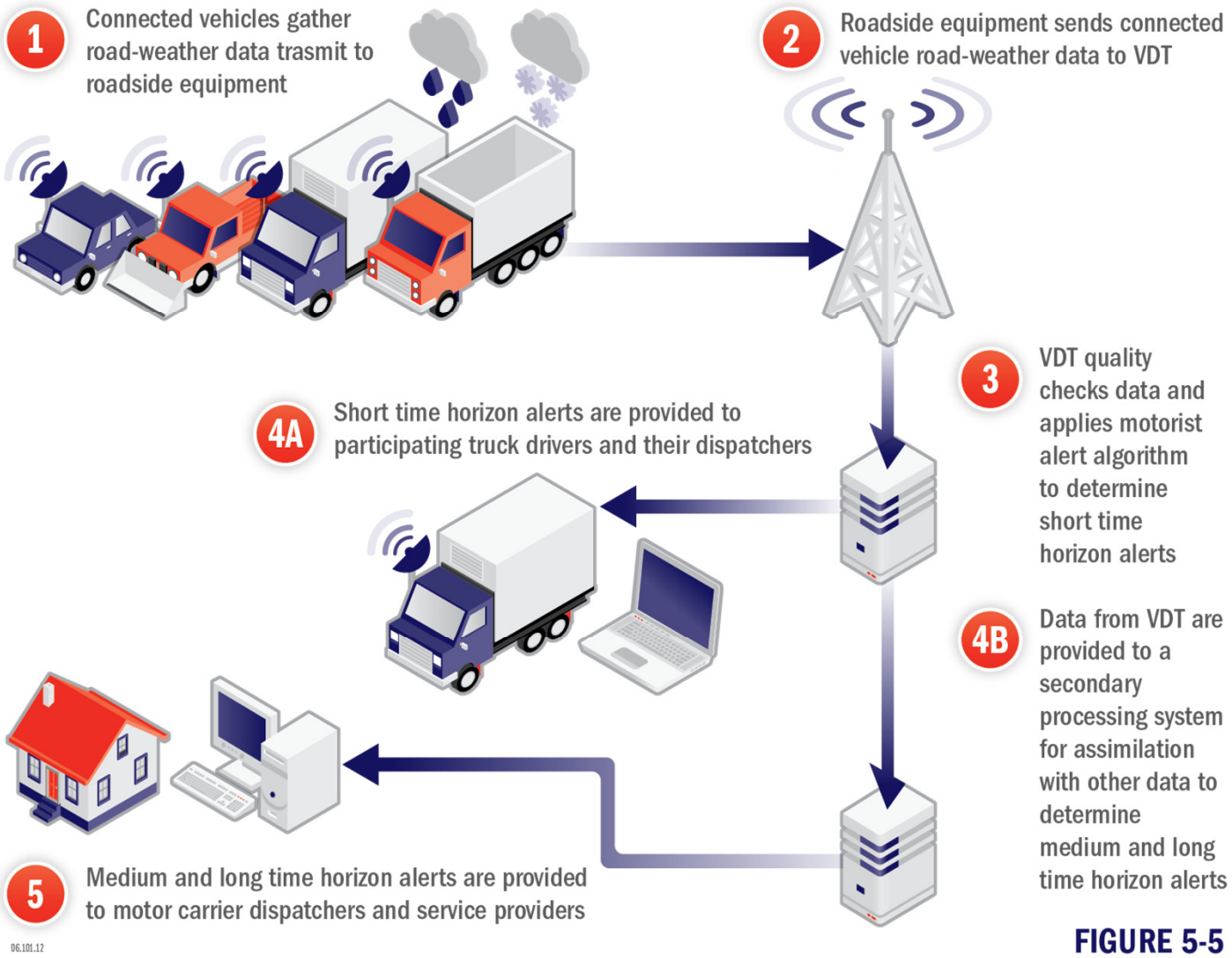


FIGURE 5-5

Information & Routing Support for Emergency Responders

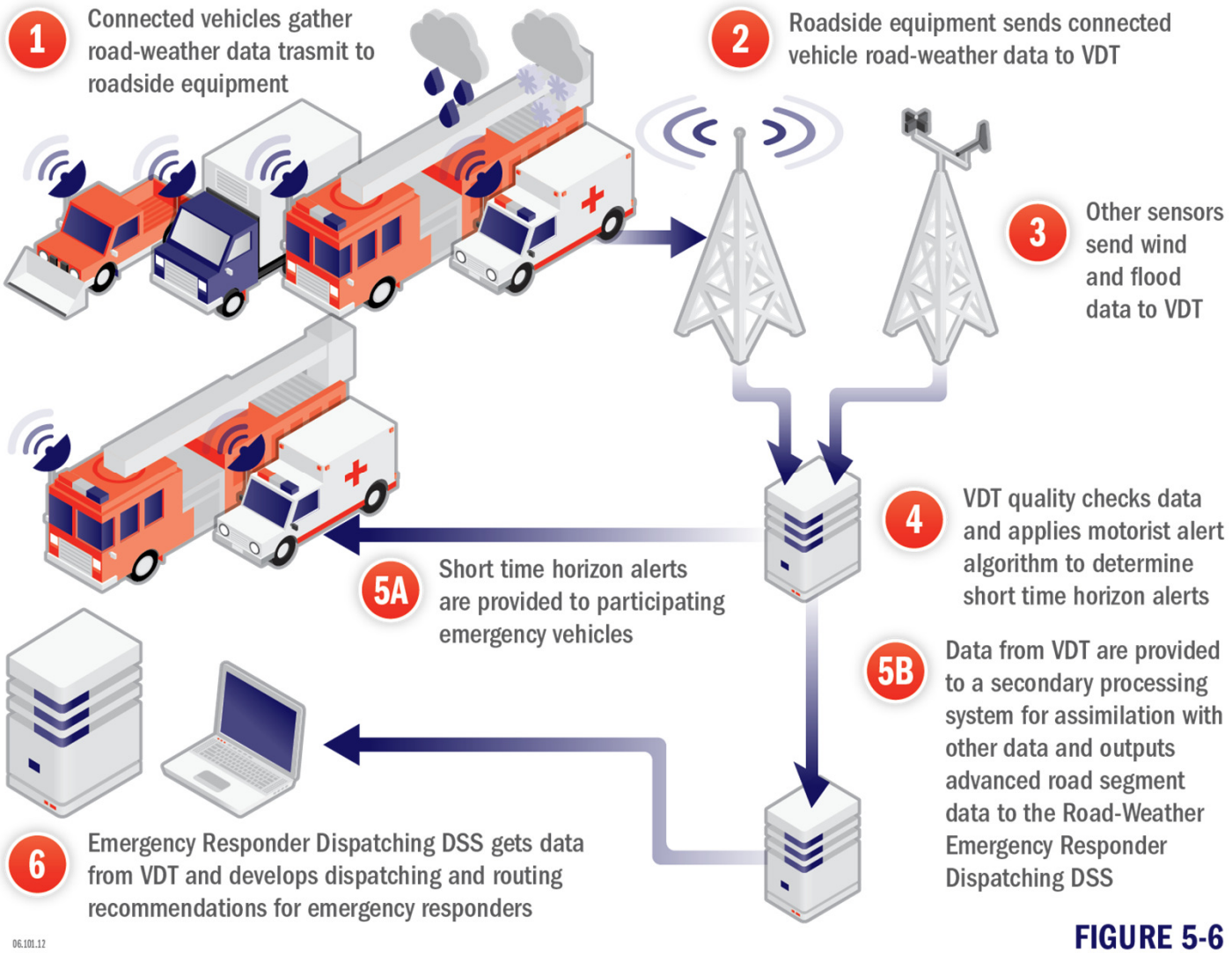
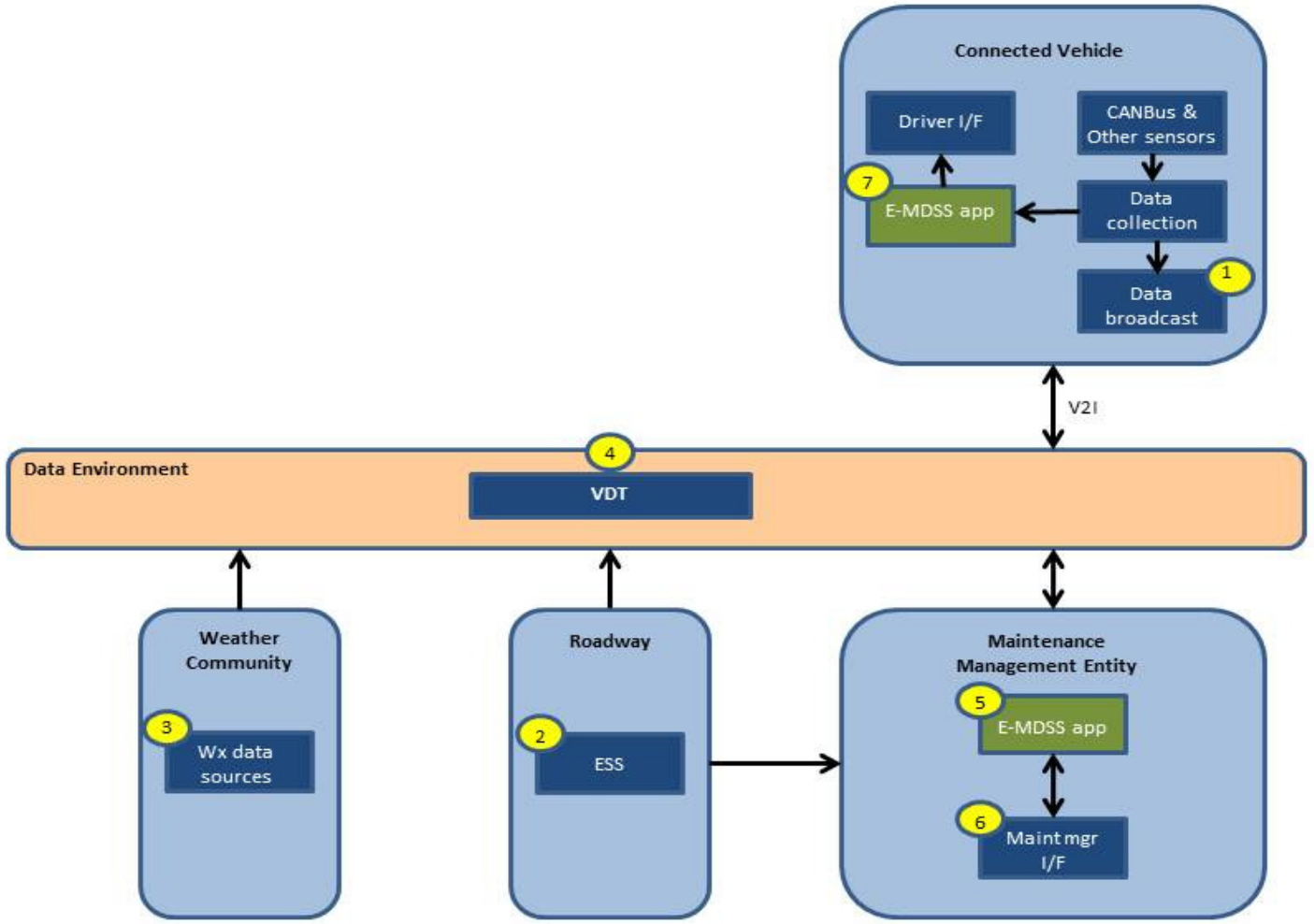
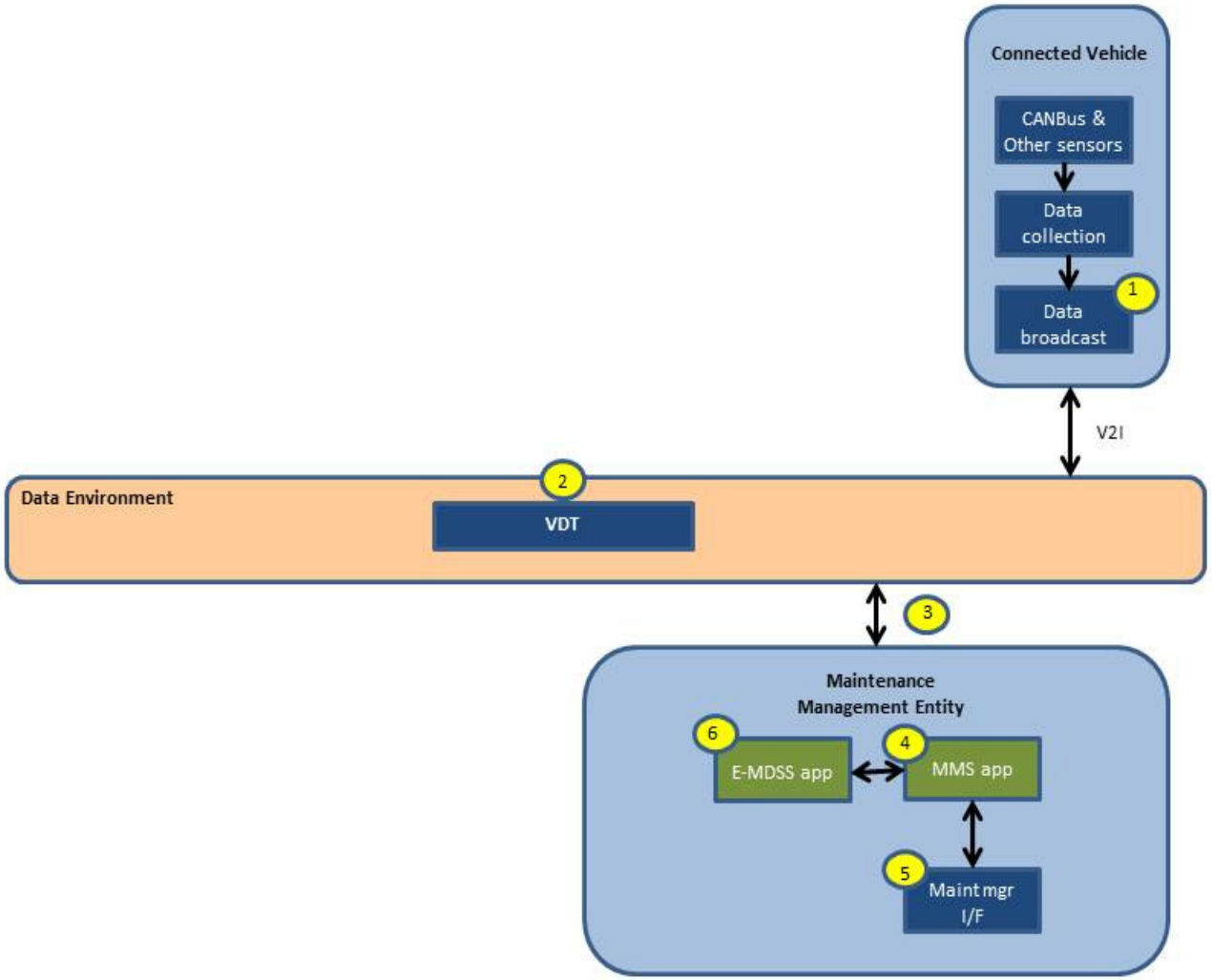


FIGURE 5-6

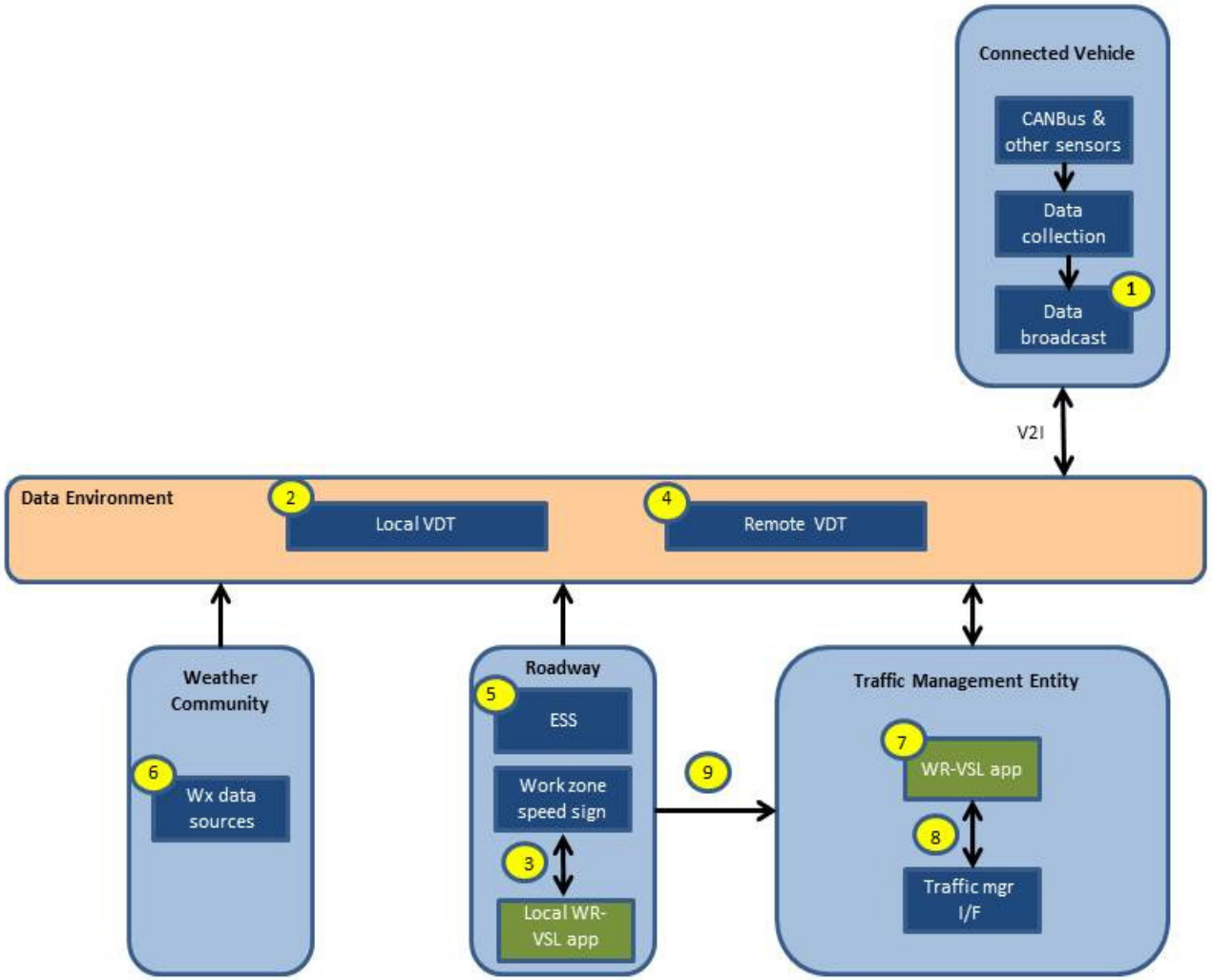
Enhanced-MDSS



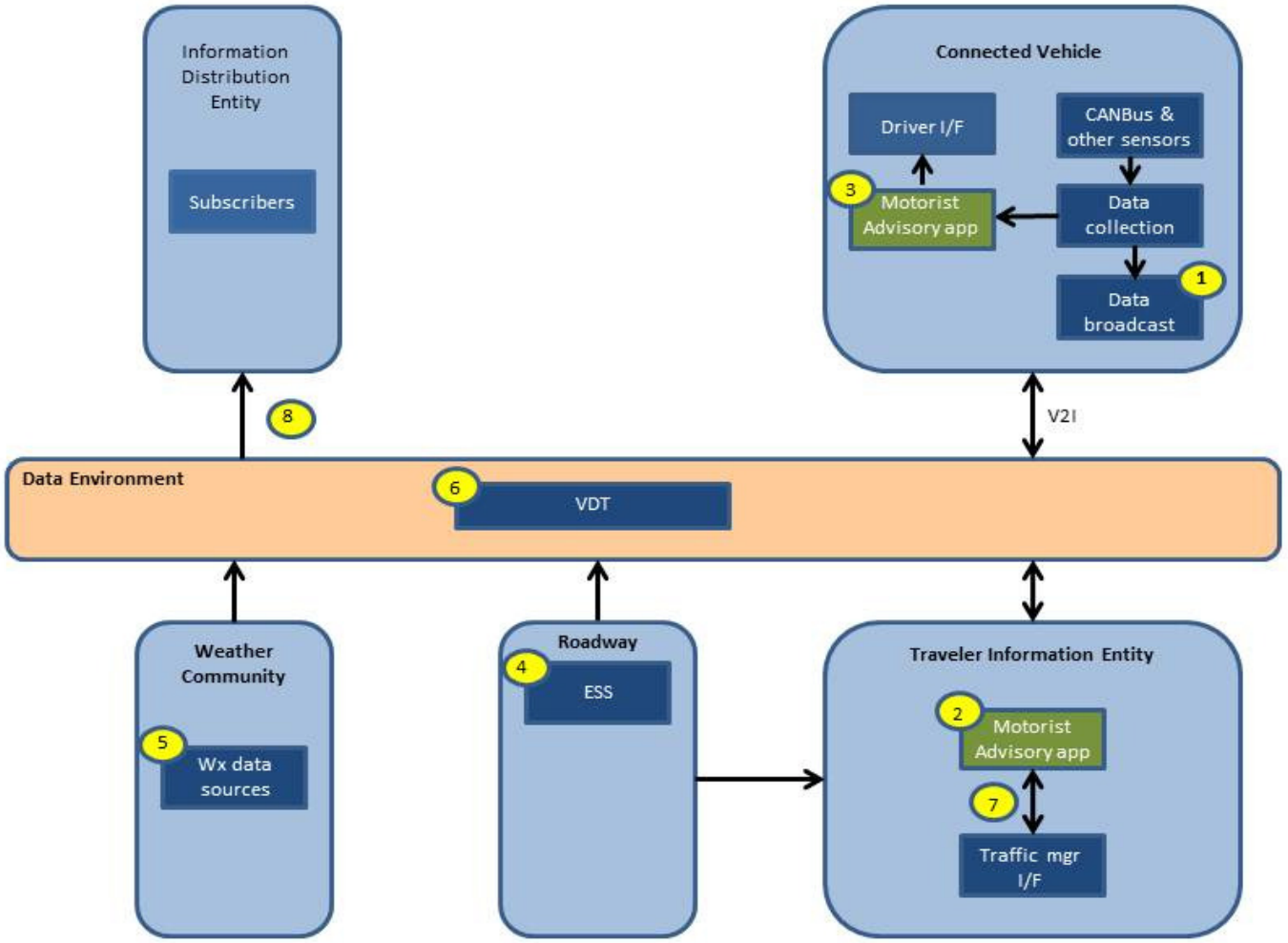
Maintenance and Fleet Management System



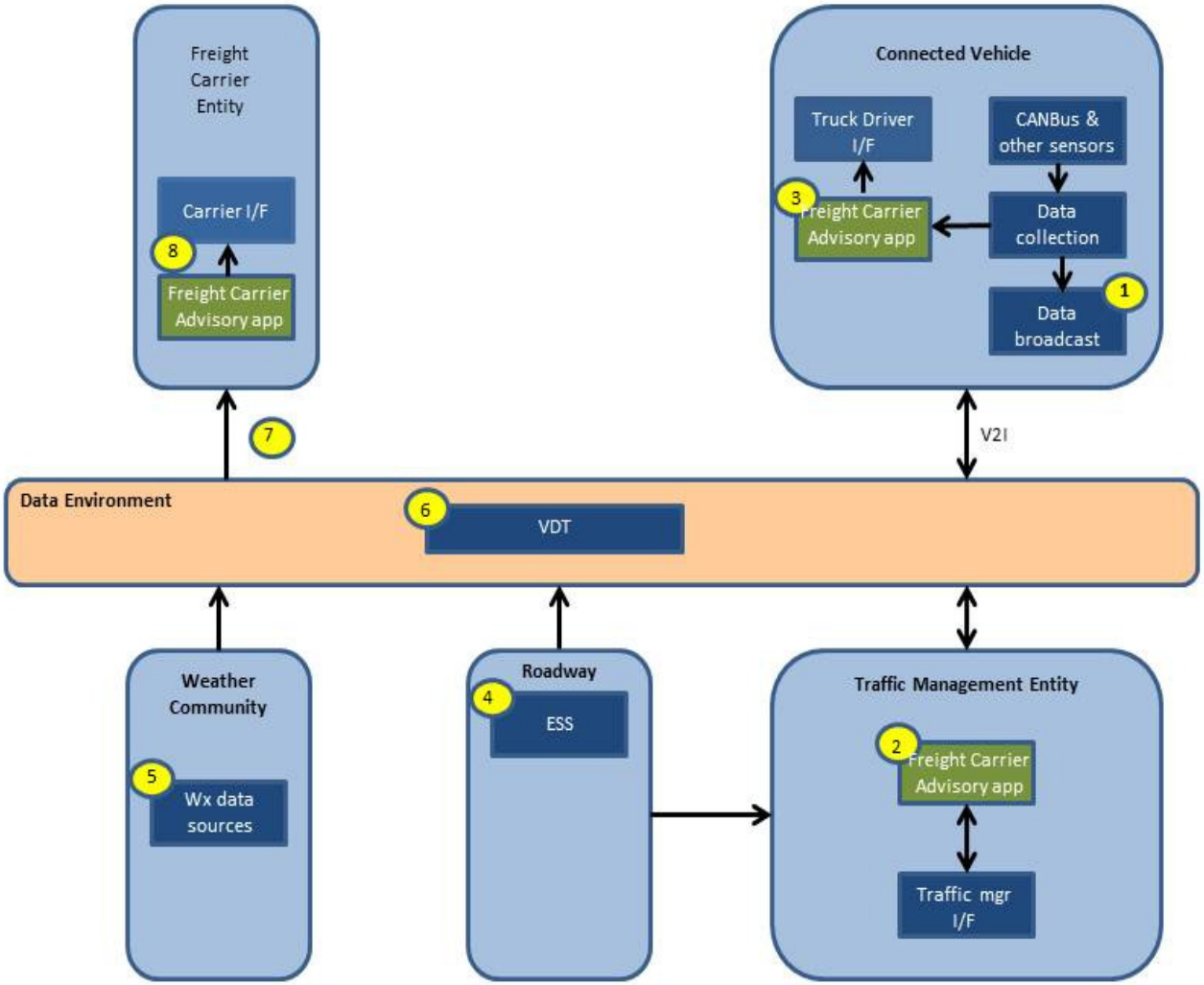
Variable Speed Limits for WRTM



Motorist Advisory and Warning System



Information for Freight Carriers



Information and Routing Support for Emergency Responders